Name ____________________ Class ______________ Date __________

Chapter 12 Rotational Motion

Summary

THE BIG IDEA **Rotating objects tend to keep rotating while nonrotating objects tend to remain nonrotating.**

12.1 Rotational Inertia

The greater the rotational inertia, the more difficult it is to change the rotational speed of an object.

- The resistance of an object to changes in its rotational motion is called **rotational inertia,** or *moment of inertia.*
- A torque is required to change the rotational state of motion of an object.
- Rotational inertia depends on mass and how the mass is distributed. The greater the distance between an object's mass concentration and the axis of rotation, the greater the rotational inertia.
- A short pendulum has less rotational inertia and therefore swings back and forth more frequently than a long pendulum. Likewise, bent legs swing back and forth more easily than outstretched legs.
- Formulas to calculate rotational inertia for different objects vary and depend on the shape of an object and the location of the rotational axis.

12.2 Rotational Inertia and Gymnastics

The three principal axes of rotation in the human body are the longitudinal axis, the transverse axis, and the medial axis.

- The three axes of rotation in the human body are at right angles to one another. All three axes pass through the center of gravity of the body.
- The vertical axis that passes from head to toe is the *longitudinal axis.* Rotational inertia about this axis is increased by extending a leg or the arms.
- You rotate about your *transverse axis* when you perform a somersault or a flip. Tucking in your arms and legs reduces your rotational inertia about the transverse axis; straightening your arms and legs increases your rotational inertia about this axis.
- The third axis of rotation for the human body is the front-to-back axis, or *medial axis.* You rotate about the medial axis when executing a cartwheel.

12.3 Rotational Inertia and Rolling

Objects of the same shape but different sizes accelerate equally when rolled down an incline.

- An object with a greater rotational inertia takes more time to get rolling than an object with a smaller rotational inertia. A hollow cylinder, for example, rolls down an incline much slower than a solid cylinder.
- All objects of the same shape roll down an incline with the same acceleration, even if their masses are different.

12.4 Angular Momentum

Newton's first law of inertia for rotating systems states that an object or system of objects will maintain its angular momentum unless acted upon by an unbalanced external torque.

- All moving objects have momentum.
- **Linear momentum** is the product of the mass and velocity of an object.
- Rotating objects have angular momentum. **Angular momentum** is the product of rotational inertia, I, and rotational velocity, ω.

$$\text{angular momentum} = \text{rotational inertia} \times \text{rotational velocity or}$$
$$\text{angular momentum} = I \times \omega$$

- When a direction is assigned to rotational speed, it is called **rotational velocity.**
- When an object is small compared with the radial distance to its axis of rotation, its angular momentum is equal to the magnitude of its linear momentum, mv, multiplied by the radial distance, r.

$$\text{angular momentum} = mvr$$

- A moving bicycle is easier to balance than a bicycle at rest because of the angular momentum provided by the spinning wheels.

12.5 Conservation of Angular Momentum

Angular momentum is conserved when no external torque acts on an object.

- The **law of conservation of angular momentum** states that if no unbalanced external torque acts on a rotating system, the angular momentum of the system is constant.
- A person who spins with arms extended obtains greater rotational speed when the arms are drawn in. In other words, whenever a rotating body contracts, its rotational speed increases.
- Zero-angular-momentum twists and turns are performed by turning one part of the body against the other.

12.6 Simulated Gravity

From within a rotating frame of reference, there seems to be an outwardly directed centrifugal force, which can simulate gravity.

- Occupants in today's space vehicles feel weightless because they lack a support force. Future space habitats will probably spin, effectively supplying a support force that simulates gravity.
- We experience 1 g on Earth's surface due to gravity. Small-diameter space structures would have to rotate at high speeds to provide a simulated gravitational acceleration of 1 g.